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On October 30, 2002

TOWNSEND and TOWNSEND and CREW LLP

By: Andrea [signature]

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

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In re application of: DAVID CHEUNG et al. Application No.: 09/418,818 Filed: October 15, 1999 For: METHOD AND APPARATUS FOR DEPOSITING ANTIREFLECTIVE COATING	Examiner: Rudy Zervigon Art Unit: 1763 APPELLANT'S BRIEF UNDER 37 CFR § 1.192

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

Applicants, in the above-captioned patent application, appeal the final rejection of claims 1-10 and 44-62. The claims on appeal have been finally rejected pursuant to MPEP § 706.07(b). Accordingly, this appeal is believed to be proper. This appeal brief is filed in triplicate.

I. <u>REAL PARTY IN INTEREST:</u>

The real party in interest for the above-identified application is APPLIED MATERIALS, INC., a Delaware corporation having its principal place of business at P.O. Box 450A, Santa Clara, California 95052. The assignment is recorded in the U.S. Patent and Trademark Office on June 28, 1996 at Reel 8078/Frame 0829.

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II. RELATED APPEALS AND INTERFERENCES:

There are no appeals or interferences related to the present appeal.

III. STATUS OF CLAIMS:

Claims 1-10 and 44-62 are pending.

Claims 44, 45, and 62 stand rejected under 35 U.S.C. § 102(b) as being anticipated by Felts et al. (USP 4,888,199), as demonstrated by M.K. Puchert et al.

Claims 1 and 7 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Felts et al. (USP 5,365,665).

Dependent claims 2-6, 9, and 10 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Felts '665 as applied to claim 1, and further in view of Dory (USP 4,877,641).

Dependent claims 46-48 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Felts '199 as applied to claims 44 and 45 above, and further in view of Felts '665.

Dependent claims 49-52 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Felts '199 as applied to claims 44-48 above, and further in view of Felts '665 and Dory.

Claims 53-59 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Felts '665 as applied to claim 49 above, and further in view of Felts '199 and Dory.

Claims 8, 60, and 61 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Felts '665 in view of Lee (USP 5,286,581).

IV. STATUS OF AMENDMENTS:

Applicants filed a Response to Office Action under 37 C.F.R. § 1.116 on July 2, 2002.

In an Advisory Action dated July 31, 2001, the Examiner maintained the rejection of all pending claims.

In accordance with 37 C.F.R. § 1.192(c)(9), a copy of the claims involved in the appeal are contained in the Appendix attached hereto.

V. SUMMARY OF THE INVENTION:

Embodiments of the present invention provide a method and an apparatus for depositing an antireflective layer. Helium gas is used to lower the deposition rate of plasma-enhanced silane oxide, silane oxynitride, and silane nitride processes. Helium is also used to stabilize the process, so that different films an be deposited. The invention provides conditions under which process parameters can be controlled to produce antireflective layers with varying optimum refractive index, absorptive index, and thickness for obtaining the desired optical behavior.

In specific embodiments, a substrate processing system comprises a vacuum chamber, a substrate supporter located within the vacuum chamber for holding a substrate, a gas manifold for introducing process gases into the chamber, and a gas distribution system coupled to the gas manifold for distributing the process gases to the gas manifold from gas sources. A power supply is coupled to the gas manifold. The system further comprises a vacuum system for controlling pressure within the vacuum chamber, and a controller, including a computer, for controlling the gas distribution system, the power supply and the vacuum system. A memory is coupled to the controller and comprises a computer readable medium having a computer readable program code embodied therein for directing operation of the substrate processing system.

In one embodiment, the computer readable program code includes computer readable program code for causing the gas distribution system to introduce a first process gas comprising a mixture of SiH_4 and N_20 into the chamber to deposit a first plasma enhanced CVD layer over the wafer, and computer readable program code for causing the gas distribution system to introduce a second process gas comprising He into the chamber to control the deposition rate of the first layer.

In another embodiment, the computer readable program code includes a first set of computer instructions for controlling the gas delivery system to introduce selected deposition gases into the process chamber at deposited gas flow rates, and a second set of computer instructions for controlling the gas delivery system to add a flow of an inert gas to the selected deposition gases at a flow rate previously determined to achieve a desired low deposition rate from a plasma enhanced reaction of the selected deposition gases. The desired

low deposition rate is lower than a deposition rate using the selected deposition gases at the deposition gas flow rates with a lower flow rate of the inert gas. A third set of computer instructions is included for controlling the power supply to supply power to the process chamber to produce a plasma enhanced reaction of the deposition gases in the process chamber to deposit a film at the low deposition rate.

In another embodiment, the computer readable program includes a first set of computer instructions for controlling the gas delivery system to flow He into the process chamber at a selected flow rate to provide a chamber pressure in the range of 1-6 Torr, a second set of computer instructions for controlling the RF power supply to supply power of 50-500 Watts to the process chamber, a third set of computer instructions for controlling the heater to heat the substrate to a temperature in the range of 200-400°C, a fourth set of computer instructions for controlling the gas delivery system to flow SiH_4 at a flow rate of 5-300 sccm into the process chamber, and a fifth set of computer instructions to flow N_2O at a flow rate of 5-300 sccm into the process chamber. A ratio of the selected flow rate of He to the combined flow rate of SiH_4 and N_2O is at least 6.25:1 to deposit an antireflective layer on the substrate at a deposition rate which is lower than a deposition rate using the same flow rate of SiH_4 and the same flow rate of N_2O with a lower flow rate of He.

In another embodiment, the computer readable program includes a first set of computer instructions for controlling the gas delivery system to flow selected deposition gases into the process chamber at deposition gas flow rates, and a second set of computer instructions for controlling the gas delivery system to add a flow of an inert gas to the selected deposition gases at a flow rate previously determined to achieve a desired low deposition rate from a reaction of the selected deposition gases. The desired low deposition rate is lower than a deposition rate using the selected deposition gases at the deposition gas flow rates with a lower flow rate of the inert gas. A third set of computer instructions is provided for controlling the power supply to supply power to the process chamber to react the deposition gases to deposit a film at the low deposition rate.

In some embodiments, the system comprises means for forming a layer of photoresist on the antireflective layer, and means for forming a photoresist pattern by exposing the photoresist layer to the exposure light and developing the exposed photoresist layer. The

antireflective layer has a thickness and refractive indices such that a first reflection from an interface between the photoresist and the antireflective layer of an exposure light will be an odd number which is at least 3 multiplied by 180° out of phase with a second reflection from an interface between the antireflective layer and the substrate layer of the exposure light.

In some embodiments, the system comprises means for forming an SiON antireflective layer over a first layer on the substrate by flowing selected deposition gases into the substrate processing chamber at deposition gas flow rates and adding a flow of an inert gas to the selected deposition gases to deposit the SiON antireflective layer at a desired deposition rate which is lower than a deposition rate using the selected deposition gases at the deposition gas flow rates with a lower flow rate of the inert gas, means for forming a layer of photoresist over the antireflective layer, and means for forming a photoresist pattern by exposing the photoresist layer to an exposure light having a wavelength of 365 nm or less and developing the exposed photoresist layer. The antireflective layer has a refractive index in the range of 1.7-2.9, an absorptive index in the range of 0-1.3, and a thickness in the range of 200-3000 angstroms. A phase shift of an odd multiple of at least 3 multiplied by 180° exists between a first reflection of the exposure light from an interface between the photoresist layer and the antireflective layer and a second reflection of the exposure light from an interface between the antireflective layer and the first layer. The first reflection has almost the same intensity as the second reflection to thereby substantially cancel the first and second reflections.

VI. ISSUES:

The following issues are presented:

Whether claims 44, 45, and 62 are properly rejected under 35 U.S.C. § 102(b) as being anticipated by Felts et al. (USP 4,888,199), as demonstrated by M.K. Puchert et al.

Whether claims 1 and 7 are properly rejected under 35 U.S.C. § 103(a) as being unpatentable over Felts et al. (USP 5,365,665).

Whether claims 2-6, 9, and 10 are properly rejected under 35 U.S.C. § 103(a) as being unpatentable over Felts '665, and further in view of Dory (USP 4,877,641).

Whether claims 46-48 are properly rejected under 35 U.S.C. § 103(a) as being unpatentable over Felts '199, and further in view of Felts '665.

Whether claims 49-52 are properly rejected under 35 U.S.C. § 103(a) as being unpatentable over Felts '199, and further in view of Felts '665 and Dory.

Whether claims 53-59 are properly rejected under 35 U.S.C. § 103(a) as being unpatentable over Felts '665, and further in view of Felts '199 and Dory.

Whether claims 8, 60, and 61 are properly rejected under 35 U.S.C. § 103(a) as being unpatentable over Felts '665 in view of Lee (USP 5,286,581).

VII. GROUPING OF THE CLAIMS:

In the present case, the rejected claims do not all stand or fall together. Applicants submit that each claim presents distinct issues concerning patentability. In the interest of administrative economy and efficiency, however, Applicants agree to narrow the issues for the purposes of this appeal only by grouping the claims as follows:

Group 1: Claims 1 and 7, which relate generally to a substrate processing system having a controller for controlling the gas distribution system, the power supply and the vacuum system, and a memory coupled to the controller comprising a computer readable medium having a computer readable program code embodied therein for directing operation of the substrate processing system, the computer readable program code including computer readable program code for causing the gas distribution system to introduce a first process gas comprising a mixture of SiH_4 and N_20 into the chamber to deposit a first plasma enhanced CVD layer over the wafer, and computer readable program code for causing the gas distribution system to introduce a second process gas comprising He into the chamber to control the deposition rate of the first layer;

Group 2: Claim 8, which is directed generally to the same subject matter as claim 7, but which includes the additional limitation that the computer readable program code for controlling the gas distribution system to operate for a specified time period comprises computer readable program code for causing the first plasma enhanced CVD layer to be formed to a thickness which is an odd multiple, greater than one, of a wavelength of light to be used in a subsequent process operation on the layer;

Group 3: Claims 2-4, 9, and 10, which are directed generally to the same subject matter as claim 1, but which include the additional limitation that the computer readable program code for causing the gas distribution system to introduce the first process gas comprising a mixture of SiH_4 and N_20 into the chamber controls the introduction of the SiH_4 to be between 5 to 300 sccm, and the rate of N_20 to be between 5 to 300 sccm;

Group 4: Claims 5 and 6, which are directed generally to the same subject matter as claim 1, but which include the additional limitation of providing computer readable program code for causing the gas distribution system to introduce a third process gas comprising NH_3 into the chamber, and computer readable program code for causing the gas distribution system to introduce a fourth process gas comprising N_2 into the chamber;

Group 5: Claims 44 and 46-48, which relate generally to a substrate process system comprising a controller configured to control the power supply and the gas delivery system, and a memory coupled to the controller comprising a computer readable medium having a computer readable program embodied therein for directing operation of the substrate processing system, the computer readable program including a first set of computer instructions for controlling the gas delivery system to introduce selected deposition gases into the process chamber at deposited gas flow rates, a second set of computer instructions for controlling the gas delivery system to add a flow of an inert gas to the selected deposition gases at a flow rate previously determined to achieve a desired low deposition rate from a plasma enhanced reaction of the selected deposition gases, the desired low deposition rate being lower than a deposition rate using the selected deposition gases at the deposition gas flow rates with a lower flow rate of the inert gas, and a third set of computer instructions for controlling the power supply to supply power to the process chamber to produce a plasma enhanced reaction of the deposition gases in the process chamber to deposit a film at the low deposition rate;

Group 6: Claim 45, which is directed generally to the same subject matter as claim 44, but which includes the additional limitation that the inert gas comprises helium;

Group 7: Claims 49-52, which are directed generally to the same subject matter as claim 44, but which include the additional limitation of a vacuum system for controlling pressure within the process chamber, wherein the computer-readable program further comprises a fourth set of computer instructions for controlling the vacuum system to maintain a chamber pressure in the range of 1-6 Torr, and wherein the selected deposition gases comprise SiH_4 flowed into the chamber at a rate of 5-300 sccm and N_2O flowed into the chamber at a rate of 5-300 sccm;

Group 8: Claim 53, which relates generally to a substrate processing system comprising a controller configured to control the power supply and the gas delivery system, and a memory coupled to the controller comprising a computer readable medium having a computer readable program embodied therein for directing operation of the substrate processing system, the computer readable program including a first set of computer instructions for controlling the gas delivery system to flow He into the process chamber at a selected flow rate to provide a chamber pressure in the range of 1-6 Torr, a second set of computer instructions for controlling the RF power supply to supply power of 50-500 Watts to the process chamber, a third set of computer instructions for controlling the heater to heat the substrate to a temperature in the range of 200-400°C, a fourth set of computer instructions for controlling the gas delivery system to flow SiH_4 at a flow rate of 5-300 sccm into the process chamber, and a fifth set of computer instructions to flow N_2O at a flow rate of 5-300 sccm into the process chamber, wherein a ratio of the selected flow rate of He to the combined flow rate of SiH_4 and N_2O is at least 6.25:1 to deposit an antireflective layer on the substrate at a deposition rate which is lower than a deposition rate using the same flow rate of SiH_4 and the same flow rate of N_2O with a lower flow rate of He;

Group 9: Claim 54, which relates generally to a substrate processing system comprising a controller configured to control the power supply and the gas delivery system, and a memory coupled to the controller comprising a computer readable

medium having a computer readable program embodied therein for directing operation of the substrate processing system, the computer readable program including a first set of computer instructions for controlling the gas delivery system to flow selected deposition gases into the process chamber at deposition gas flow rates, a second set of computer instructions for controlling the gas delivery system to add a flow of an inert gas to the selected deposition gases at a flow rate previously determined to achieve a desired low deposition rate from a reaction of the selected deposition gases, the desired low deposition rate being lower than a deposition rate using the selected deposition gases at the deposition gas flow rates with a lower flow rate of the inert gas, and a third set of computer instructions for controlling the power supply to supply power to the process chamber to react the deposition gases to deposit a film at the low deposition rate;

Group 10: Claims 55 and 56, which relate generally to a substrate processing system comprising means for adding a flow of an inert gas to the selected deposition gases at a flow rate previously determined to achieve a desired low deposition rate from plasma enhanced reaction of the selected deposition gases, the desired low deposition rate being lower than a deposition rate using the selected deposition gases at the deposition gas flow rates with a lower flow rate of the inert gas; and means for depositing a thin film at the low deposition rate from a plasma enhanced reaction of the deposition gases;

Group 11: Claims 57-59, which relate generally to a substrate processing system comprising means for flowing He into the processing chamber at a selected flow rate to provide a chamber pressure in the range of 1-6 Torr; means for connecting the chamber to an RF power supply to receive 50-500 Watts; means for heating the substrate to a temperature in the range of 200-400°C; means for flowing SiH4 through a gas distribution system at a flow rate of 5-300 sccm; and means for flowing N_2O through the gas distribution system at a flow rate of 5-300 sccm, wherein a ratio of the selected flow rate of He to the combined flow rate of SiH_4 and N_2O is at least 6.25:1 to deposit an antireflective layer on

the substrate at a deposition rate which is lower than a deposition rate using the same flow rate of SiH_4 and the same flow rate of N_2O with a lower flow rate of He;

Group 12: Claim 60, which relates generally to a substrate processing system comprising means for forming an antireflective layer over a layer on the substrate by flowing selected deposition gases into the substrate processing chamber at deposition gas flow rates and adding a flow of an inert gas to the selected deposition gases to deposit the antireflective layer at a desired deposition rate which is lower than a deposition rate using the selected deposition gases at the deposition gas flow rates with a lower flow rate of the inert gas; means for forming a layer of photoresist on the antireflective layer, the antireflective layer having a thickness and refractive indices such that a first reflection from an interface between the photoresist and the antireflective layer of an exposure light will be an odd number which is at least 3 multiplied by 180° out of phase with a second reflection from an interface between the antireflective layer and the substrate layer of the exposure light; and means for forming a photoresist pattern by exposing the photoresist layer to the exposure light and developing the exposed photoresist layer;

Group 13: Claim 61, which relates generally to a substrate processing system comprising means for forming an SiON antireflective layer over a first layer on the substrate by flowing selected deposition gases into the substrate processing chamber at deposition gas flow rates and adding a flow of an inert gas to the selected deposition gases to deposit the SiON antireflective layer at a desired deposition rate which is lower than a deposition rate using the selected deposition gases at the deposition gas flow rates with a lower flow rate of the inert gas, said antireflective layer having a refractive index in the range of 1.7-2.9, an absorptive index in the range of 0-1.3, and a thickness in the range of 200-3000 angstroms; means for forming a layer of photoresist over the antireflective layer; and means for forming a photoresist pattern by exposing the photoresist layer to an exposure light having a wavelength of 365 nm or less and

developing the exposed photoresist layer, wherein a phase shift of an odd multiple of at least 3 multiplied by 180° exists between a first reflection of the exposure light from an interface between the photoresist layer and the antireflective layer and a second reflection of the exposure light from an interface between the antireflective layer and the first layer, the first reflection having almost the same intensity as the second reflection to thereby substantially cancel the first and second reflections; and

Group 14: Claim 62, which relates generally to a substrate processing system comprising means for flowing selected deposition gases into the substrate processing chamber at deposition gas flow rates; means for adding a flow of an inert gas to the selected deposition gases at a flow rate previously determined to achieve a desired low deposition rate from a reaction of the selected deposition gases, said desired low deposition rate being lower than a deposition rate using said selected deposition gases at said deposition gas flow rates with a lower flow rate of said inert gas; and means for depositing a thin film on the substrate at said low deposition rate from said reaction of said deposition gases.

VIII. DISCUSSION OF THE REFERENCES RELIED UPON BY THE EXAMINER:

In rejecting the claims under 35 U.S.C. §§ 102(b) and 103(a), the Examiner relied upon the following references:

1. Felts et al. (United States Patent No. 4,888,199)

Felts '199 discloses a process of depositing a thin film onto a surface of a substrate with the use of a plasma. Felts '199 discloses the use of the average electron temperature of the plasma T_e to diagnose and control the plasma deposition. "The average electron temperature of the plasma affects the film deposition rate and properties of the resulting film, so it is an important piece of information to have in a real time plasma control system." Column 2, lines 47-51. Thus, Felts '199 is concerned with achieving a desired average electron temperature of the plasma (col. 2, line 58, to col. 3, line 6). The system adjusts the helium gas flow to the plasma chamber. "An increase of the inert gas supply provides more electrons, and a decrease in the gas fewer electrons." Column 10, lines 48-50.

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2. M.K. Puchert et al.

Puchert et al. discloses a study on "the interaction between the metal plasma beam of a filtered cathodic arc and the noble gases helium neon, and argon introduced into the beam path" (page 3493, col. 1, lines 27-30). Puchert et al. discloses a decrease in deposition rate of copper as the pressure and ion current increase.

3. Felts et al. (United States Patent No. 5,365,665)

Felts '665 discloses a plasma treating apparatus useful for coating substrates with thin films having vapor barrier properties at relatively rapid deposition rates. The method for rapid plasma treatments uses an inert gas (helium or argon) with an organosilicon compound and oxygen of the gas stream to deposit a film. "When the inert gas is helium or argon, then a suitable flow rate ratio of organosilicon compound, oxygen and inert gas is about 0.1:1.0:1.0. Other flow rate ratios may be used, however, if desirable." Column 5, lines 17-20.

4. Dory (United States Patent No. 4,877,641)

Dory discloses a plasma CVD process for forming silicon nitride-type or silicon dioxide-type films onto a substrate by introducing di-tert-butylsilane and at least one other reactant gas into a CVD reaction zone. For the reactant gas, the "preferred gas flow rate ranges are about 200-700 sccm for N_2, about 2 to about 3000 sccm for anhydrous ammonia, about 200-3000 sccm for nitrous oxide, and about 0-4000 sccm for nitric oxide." Column 3, lines 39-42.

5. Lee (United States Patent No. 5,286,581)

Lee discloses a method for fabricating a phase-shift mask. To achieve the optimal phase shift of 180 degrees, $d = L / (2(n-1))$, where d is the thickness of the phase-shift layer, L is the wavelength of illumination (e.g., 365 nm), and n is the refractive index of phase-shift feature, which is approximately 2.05 for Si_3N_4. The thickness d of Si_3N_4 is 1.738 angstroms. Column 5, lines 10-29.

IX. ARGUMENTS:

Because all the claims do not stand or fall together, Applicants will present arguments for each claim group.

PATENT

Claim Group 1

Claims 1 and 7 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Felts '6~~5~~5. Applicants respectfully submit that independent claim 1 and claim 7 depending therefrom are patentable over Felts '665 because, for instance, Felts '665 does not teach or suggest computer readable program code for causing the gas distribution system to introduce a second process gas comprising He into the chamber to control the deposition rate of the first layer. 6 6-20

The Examiner cites Felts '665 at ~~column 5, lines 13-20,~~ 42 for allegedly anticipating this feature of the claim. Felts '665 merely discloses the use of an inert gas (helium or argon) with an organosilicon compound and oxygen of the gas stream to deposit a film. Nothing in Felts '665 discloses or suggests introducing a process gas comprising He to control the deposition rate of the PECVD deposition layer from the recited process gases. Thus, claims 1 and 7 are patentable.

Claim Group 2

Claim 8 depends from claim 7, and stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Felts '665 in view of Lee. Applicants believe claim 8 is allowable for the same reasons that claim 7 is allowable since Lee does not cure the deficiencies of Felts '665. Claim 8 further recites that the computer readable program code for controlling the gas distribution system to operate for a specified time period comprises computer readable program code for causing the first plasma enhanced CVD layer to be formed to a thickness which is an odd multiple, greater than one, of a wavelength of light to be used in a subsequent process operation on the layer.

The Examiner cites Lee for merely disclosing that a first reflection from an interface between the photoresist layer and the antireflective layer of an exposure light is an odd number, but it is <u>not</u> at least 3 multiplied by 180° (π in radians) out of phase with a second reflection from an interface between the antireflective layer and the substrate layer of the exposure light. Nothing in Lee teaches or suggests a thickness that is an odd multiple, greater than one, of the wavelength.

The specification at page 10, line 14, to page 11, line 14, describes a number of advantages of using thicker antireflective layers by selecting a thickness that is an odd

multiple, greater than one, of a wavelength of light to be used in a subsequent process operation on the layer. For instance, the increased thickness achieves improved film consistency from wafer to wafer; provides better control of the refractive index, absorptive index, and thickness of the film; and renders the film suitable for use as a hard mask during an etching step. These are not disclosed in Lee.

Even if combined, therefore, Felts '665 and Lee do not render claim 8 unpatentable. Accordingly, claim 8 is patentable.

Claim Group 3

Claims 2-4 and 9-10 depend from claim 1, and stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Felts '665 as applied to claim 1, and further in view of Dory. Applicants believe claims 2-4 and 9-10 are allowable for the same reasons that claim 1 is allowable, since Dory does not cure the deficiencies of Felts '665. Claims 3-4 and 9-10 depend from claim 2, which recites that the computer readable program code for causing the gas distribution system to introduce the first process gas comprising a mixture of SiH_4 and N_20 into the chamber controls the introduction of the SiH_4 to be between 5 to 300 sccm, and the rate of N_20 to be between 5 to 300 sccm. These features are also absent from Felts '665 and Dory. Dory merely discloses reacting gases with DTBS. Thus, claims 2-4 and 9-10 are patentable.

Claim Group 4

Claims 5 and 6 depend from claim 1, and stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Felts '665 as applied to claim 1, and further in view of Dory. Applicants believe claims 5 and 6 are allowable for the same reasons that claim 1 is allowable since Dory does not cure the defects of Felts '665. Claim 6 depends from claim 5, which recites computer readable program code for causing the gas distribution system to introduce a third process gas comprising NH_3 into the chamber, and computer readable program code for causing the gas distribution system to introduce a fourth process gas comprising N_2 into the chamber. Dory merely discloses reacting gases with DTBS. Therefore, claims 5 and 6 are patentable.

Claim Group 5

Claim 44 stands rejected under 35 U.S.C. § 102(b) as being anticipated by Felts '199, as demonstrated by Puchert et al. Claims 46-48 depend from claim 44, and stand rejected

under 35 U.S.C. § 103(a) as being unpatentable over Felts '199 as applied to claim 44, and further in view of Felts '665.

Applicants respectfully assert that independent claim 44 is novel and patentable over Felts '199 because, for instance, Felts '199 does not teach or suggest adding a flow of an inert gas to the selected deposition gases at a flow rate previously determined to achieve a desired low deposition rate from a plasma enhanced reaction of the selected deposition gases, wherein the desired deposition rate is lower than a deposition rate using the selected deposition gases at the deposition gas flow rates with a lower flow rate of the inert gas.

The Examiner alleges that Felts '199 anticipates the claimed relationship of deposition rates and that "the addition of He increases electron density in the plasma (column 10, lines 47-50) which anticipates the effect of reduced deposition rates considering the fact that these added electrons would effectively shield cations thereby reducing one of the chemical mechanisms of PECVD." Felts '199 is completely devoid of teaching or suggesting this relationship.

Felts '199 discloses the use of the average electron temperature of the plasma T_e to diagnose and control the plasma deposition. "The average electron temperature of the plasma affects the film deposition rate and properties of the resulting film, so it is an important piece of information to have in a real time plasma control system." Column 2, lines 47-51. There is nothing in Felts '199 that suggests "added electrons would effectively shield cations thereby reducing one of the chemical mechanisms of PECVD," as alleged by the Examiner. Nor does Felts '199 suggest controlling the gas delivery system to add a flow of an inert gas to the selected deposition gases at a flow rate previously determined to achieve a desired low deposition rate from a plasma enhanced reaction of the selected deposition gases, wherein the desired deposition rate is lower than a deposition rate using the selected deposition gases at the deposition gas flow rates with a lower flow rate of the inert gas, as recited in claim 44. In contrast, Felts '199 is concerned with achieving a desired average electron temperature of the plasma (col. 2, line 58, to col. 3, line 6).[1]

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[1] "By taking another ratio of two emissions lines, one produced by a species that necessarily absorbs a high energy from electron collisions with it and another from a species having a probability of having absorbed much lower energy from electron collisions with it to give the measured emission, a declining 'tail' of an electron energy (temperature) distribution within the plasma can be monitored and controlled. It has been found that high energy electrons in the

The Examiner cites Puchert et al. for allegedly demonstrating the relationship between plasma vapor deposition and He electron density. Puchert et al. discloses a decrease in deposition rate of copper as the pressure and ion current increase.

Puchert et al. is directed to "the interaction between the metal plasma beam of a filtered cathodic arc and the noble gases helium neon, and argon introduced into the beam path" (page 3493, col. 1, lines 27-30). Puchert et al. discloses a decrease in deposition rate of copper as the pressure and ion current increase. There is no basis to believe that the results of copper deposition from a metal plasma beam of a filtered cathodic arc can be generalized to plasma-enhanced chemical vapor deposition (PECVD) of a dielectric layer. The deposition mechanism, deposition apparatus, nature of film deposited are <u>fundamentally different</u>. The Examiner's assertions are based on nothing more than speculation.

Indeed, a more pertinent prior art reference discloses deposition of a PECVD silicon nitride layer from SiH_4, N_2, and He, in which the deposition rate is positively related to the inert gas flow rate. See D.V. Tsu et al., "Local Atomic Structure in Thin Films of Silicon Nitride and Silicon Diimide Produced by Remote Plasma-Enhanced Chemical-Vapor Deposition," Physical Review B, 7069-76 (May 15, 1986). This reference was cited in the IDS filed on December 27, 1999. This is directly opposite from the claimed invention of depositing a PECVD layer from SiH_4 and N_2O in which the deposition rate is inversely related to the inert gas flow rate. Tsu et al. discloses the positive correlation of inert gas flow rate (He) and silicon nitride film deposition rate in Tables I and II; page 7071, column 1, lines 1-29; and page 7072, column 1, lines 1-9. "Additional dilution with He serves to increase the deposition rate still further." Page 7071, column 1, lines 13-14. "Increased dilution of the N_2 with He increases the deposition rate by inhibiting recombination and/or deexcitation reactions involving collisions between N atoms and nitrogen molecules." Page 7072, column 1, lines 6-9.

<u>The Examiner, however, completely ignores Tsu et al., which discloses a similar PECVD process for depositing a layer from similar gases having SiH_4, a nitrogen-</u>

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plasma can inadvertently be suppressed in the course of optimizing other variables. Therefore, a separate high energy electron density measurement reveals whether this is happening or not and allows an adjustment to be made in real time to maintain a sufficient proportion of high energy electrons in the plasma. An adequate supply of high energy electrons is important to the hardness of the resulting film." Column 2, line 58, to column 3, line 6.

source gas, and an inert gas. Instead, the Examiner relies on Puchert et al. for allegedly demonstrating the relationship between plasma vapor deposition and He electron density. Puchert, however, discloses a deposition of a fundamentally different material (copper deposition) from a fundamentally different process (a metal plasma beam of a filtered cathodic arc).

Therefore, the effect of helium dilution cannot be generalized based on Puchert et al., particularly since the deposition mechanism, the deposition apparatus, and the nature of film deposited are fundamentally different.

In sum, Puchert et al. does not provide the teaching missing in Felts '199. Tsu et al. teaches away from the claimed invention, suggesting that the claimed invention is novel and nonobvious. Therefore, claim 44 is novel over Felts '199.

Dependent claims 46-48 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Felts '199 as applied to claims 44 and 45 above, and further in view of Felts '665. As discussed above, Felts '199 fails to teach or suggest computer instructions for controlling the gas delivery system to add a flow of an inert gas to the selected deposition gases at a flow rate previously determined to achieve a desired low deposition rate from a plasma enhanced reaction of the selected deposition gases, wherein the desired deposition rate is lower than a deposition rate using the selected deposition gases at the deposition gas flow rates with a lower flow rate of the inert gas. Felts '665 does not cure this defect. Accordingly, claims 46-48 are patentable over Felts '199 and Felts '665.

Claim Group 6

Claim 45 depends from claim 44 and also stands rejected under 35 U.S.C. § 102(b) as being anticipated by Felts '199, as demonstrated by Puchert et al. Applicants believe claim 45 is allowable for the same reasons that claim 44 is allowable. Claim 45 further recites that the inert gas comprises helium. Felts '199 fails to teach or suggest adding a flow of helium to the deposition gases at a flow rate previously determined to achieve a desired low deposition rate from a plasma enhanced reaction of the selected deposition gases, wherein the desired deposition rate is lower than a deposition rate using the selected deposition gases at the deposition gas flow rates with a lower flow rate of helium. Therefore, claim 45 is novel and patentable over Felts '199.

Claim Group 7

Claims 49-52 depend from claim 44, and stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Felts '199 in view of Felts '665 and Dory. Applicants believe claims 49-52 are allowable for the same reasons that claim 44 is allowable since Dory and Felts '665 do not cure the deficiencies of Felts '199. Claim 49 from which claims 50-52 depend further recites a fourth set of computer instructions for controlling the vacuum system to maintain a chamber pressure in the range of 1-6 Torr, and wherein the selected deposition gases comprise SiH_4 flowed into the chamber at a rate of 5-300 sccm and N_2O flowed into the chamber at a rate of 5-300 sccm. These features are also absent from Felts '199, Felts '665, and Dory. Dory merely discloses reacting gases with DTBS. Therefore, claims 49-52 are patentable.

Claim Group 8

Independent claim 53 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Felts '665 in view of Felts '199 and Dory.

Claim 53 is submitted to be patentable because, for instance, the references do not disclose or suggest that a ratio of the selected flow rate of He to the combined flow rate of SiH_4 and N_2O is at least 6.25:1 to deposit an antireflective layer on the substrate at a deposition rate which is lower than a deposition rate using the same flow rate of SiH_4 and the same flow rate of N_2O with a lower flow rate of He. This feature is completely absent from the cited references. As discussed above, the references do not teach or suggest a lower deposition rate using a certain flow rate of He than using a lower flow rate of He, and Dory merely discloses reacting gases with DTBS.

Claim Group 9

Independent claim 54 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Felts '665 in view of Felts '199 and Dory.

Claim 54 is patentable because, for instance, the references do not teach or suggest computer instructions for controlling the gas delivery system to add a flow of an inert gas to the selected deposition gases at a flow rate previously determined to achieve a desired low deposition rate from a reaction of the selected deposition gases, wherein the desired low deposition rate is lower than a deposition rate using the selected deposition gases at the

deposition gas flow rates with a lower flow rate of the inert gas. As discussed above, Felts '199 merely discloses the use of the average electron temperature of the plasma T_e to diagnose and control the plasma deposition. Felts '665 merely discloses the use of an inert gas (helium or argon) with an organosilicon compound and oxygen of the gas stream to deposit a film. Dory merely discloses reacting gases with DTBS, and does not cure the defects of Felts '199 and Felts' 665. Accordingly, claim 54 is patentable.

Claim Group 10

Independent claim 55 and claim 56 depending therefrom stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Felts '665 in view of Felts '199 and Dory.

Claims 55 and 56 are patentable because, for instance, the references fail to disclose or suggest means for adding a flow of an inert gas to the selected deposition gases at a flow rate previously determined to achieve a desired low deposition rate from plasma enhanced reaction of the selected deposition gases, wherein the desired low deposition rate is lower than a deposition rate using the selected deposition gases at the deposition gas flow rates with a lower flow rate of the inert gas. As discussed above, nothing in the references suggests this feature.

Claim Group 11

Independent claim 57 and claims 58-59 depending therefrom stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Felts '665 in view of Felts '199 and Dory.

Claims 57-59 are patentable because, for instance, the references do not teach or suggest that a ratio of the selected flow rate of He to the combined flow rate of SiH_4 and N_2O is at least 6.25:1 to deposit an antireflective layer on the substrate at a deposition rate which is lower than a deposition rate using the same flow rate of SiH_4 and the same flow rate of N_2O with a lower flow rate of He. As discussed above in connection with claim group 8, this feature is completely absent from the cited references.

Claim Group 12

In dependent claim 60 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Felts '665 in view of Lee. Applicants respectfully submit that claim 60 is patentable over Felts '665 and Lee because, for instance, they do not disclose or suggest adding a flow of an inert gas to the selected deposition gases to deposit the antireflective layer at a

desired deposition rate which is lower than a deposition rate using the selected deposition gases at the deposition gas flow rates with a lower flow rate of the inert gas.

The Examiner cites Lee for merely disclosing that a first reflection from an interface between the photoresist layer and the antireflective layer of an exposure light is an odd number, but it is not at least 3 multiplied by 180° (π in radians) out of phase with a second reflection from an interface between the antireflective layer and the substrate layer of the exposure light. Nothing in Lee teaches or suggests a thickness that is an odd multiple, greater than one, of the wavelength. As discussed above, the specification at page 10, line 14, to page 11, line 14, describes a number of advantages of using thicker antireflective layers by selecting a thickness that is an odd multiple, greater than one, of a wavelength of light to be used in a subsequent process operation on the layer. For instance, the increased thickness achieves improved film consistency from wafer to wafer; provides better control of the refractive index, absorptive index, and thickness of the film; and renders the film suitable for use as a hard mask during an etching step. These are not disclosed in Lee.

Even if combined, therefore, Felts '665 and Lee do not render claim 60 unpatentable. Accordingly, claim 60 is patentable.

Claim Group 13

Claim 61 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Felts '665 in view of Lee. Applicants respectfully submit that claim 60 is patentable over Felts '665 and Lee because, for instance, they do not disclose or suggest adding a flow of an inert gas to the selected deposition gases to deposit the SiON antireflective layer at a desired deposition rate which is lower than a deposition rate using the selected deposition gases at the deposition gas flow rates with a lower flow rate of the inert gas.

The Examiner cites Lee for merely disclosing that a first reflection from an interface between the photoresist layer and the antireflective layer of an exposure light is an odd number, but it is not at least 3 multiplied by 180° (π in radians) out of phase with a second reflection from an interface between the antireflective layer and the substrate layer of the exposure light. As discussed above in connection with claim group 12, nothing in Lee teaches or suggests a thickness that is an odd multiple, greater than one, of the wavelength. Accordingly, claim 61 is patentable.

Claim Group 14

Claim 62 stands rejected under 35 U.S.C. § 102(b) as being anticipated by Felts '199, as demonstrated by M.K. Puchert et al.

Applicants respectfully assert that claim 62 is novel and patentable over Felts '199 because, for instance, Felts '199 does not teach or suggest adding a flow of an inert gas to the selected deposition gases at a flow rate previously determined to achieve a desired low deposition rate from a plasma enhanced reaction of the selected deposition gases, wherein the desired deposition rate is lower than a deposition rate using the selected deposition gases at the deposition gas flow rates with a lower flow rate of the inert gas. The Examiner alleges that Felts '199 anticipates the claimed relationship of deposition rates and that "the addition of He increases electron density in the plasma (column 10, lines 47-50) which anticipates the effect of reduced deposition rates considering the fact that these added electrons would effectively shield cations thereby reducing one of the chemical mechanisms of PECVD."

As discussed above in connection with claim group 5, Felts '199 is completely devoid of teaching or suggesting this relationship.

Indeed, Tsu et al. discloses deposition of a PECVD silicon nitride layer from SiH_4, N_2, and He, in which the deposition rate is positively related to the inert gas flow rate. The Examiner, however, completely ignores Tsu et al., which discloses a similar PECVD process for depositing a layer from similar gases having SiH_4, a nitrogen-source gas, and an inert gas. Instead, the Examiner relies on Puchert et al. for allegedly demonstrating the relationship between plasma vapor deposition and He electron density. Puchert, however, discloses a deposition of a fundamentally different material (copper deposition) from a fundamentally different process (a metal plasma beam of a filtered cathodic arc).

As discussed above, Puchert et al. is directed to "the interaction between the metal plasma beam of a filtered cathodic arc and the noble gases helium neon, and argon introduced into the beam path" (page 3493, col. 1, lines 27-30). Puchert et al. discloses a decrease in deposition rate of copper as the pressure and ion current increase. There is no basis to believe that the results of copper deposition from a metal plasma beam of a filtered cathodic arc can be generalized to plasma-enhanced chemical vapor deposition (PECVD) of a dielectric layer. The deposition mechanism, deposition apparatus, nature of film deposited are

fundamentally different. The Examiner's assertions are based on nothing more than speculation.

In sum, Puchert et al. does not provide the teaching missing in Felts '199. Tsu et al. teaches away from the claimed invention, suggesting that the claimed invention is novel and nonobvious. Therefore, claim 62 is novel over Felts '199.

X. CONCLUSION:

In view of the foregoing arguments distinguishing claims 1-10 and 44-62 over the art of record, Applicants respectfully submit that the claims are in condition for allowance, and respectfully request that the rejection of these claims be reversed.

Respectfully submitted,

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Encl.: Appendix of claims involved in appeal

APPENDIX

1. A substrate processing system, comprising:

a vacuum chamber;

a substrate supporter, located within the vacuum chamber, for holding a substrate;

a gas manifold for introducing process gases into the chamber;

a gas distribution system, coupled to the gas manifold, for distributing the process gases to the gas manifold from gas sources;

a power supply coupled to the gas manifold;

a vacuum system for controlling pressure within the vacuum chamber;

a controller, including a computer, for controlling the gas distribution system, the power supply and the vacuum system; and

a memory coupled to the controller comprising a computer readable medium having a computer readable program code embodied therein for directing operation of the substrate processing system, the computer readable program code including:

computer readable program code for causing the gas distribution system to introduce a first process gas comprising a mixture of SiH_4 and N_20 into the chamber to deposit a first plasma enhanced CVD layer over the wafer; and

computer readable program code for causing the gas distribution system to introduce a second process gas comprising He into the chamber to control the deposition rate of the first layer.

2. A substrate processing system as in claim 1 wherein the computer readable program code for causing the gas distribution system to introduce the first process gas comprising a mixture of SiH_4 and N_20 into the chamber controls the introduction of the SiH_4 to be between 5 to 300 sccm, and the rate of N_20 to be between 5 to 300 sccm.

3. A substrate processing system as in claim 2 wherein the computer readable program code for causing the gas distribution system to introduce a second process gas comprising He into the chamber controls the chamber pressure at about 1 to 6 torr, the chamber pressure being the pressure inside the chamber.

4. A substrate processing system as in claim 3 wherein the computer readable program code for causing the gas distribution system to introduce the first process gas comprising a mixture of SiH_4 and N_20 into the chamber controls the introduction of the SiH_4 to be at a volumetric flow rate of between 0.5 to 3 times the volumetric flow rate of N_20.

5. A substrate processing system as in claim 1 further comprising:

computer readable program code for causing the gas distribution system to introduce a third process gas comprising NH_3 into the chamber; and

computer readable program code for causing the gas distribution system to introduce a fourth process gas comprising N_2 into the chamber.

6. A substrate processing system as in claim 5 wherein:

the computer readable program code for causing the gas distribution system to introduce a third process gas comprising NH_3 into the chamber controls the introduction of the NH_3 to be between a rate of 0 to 300 sccm; and

the computer readable program code for causing the gas distribution system to introduce a fourth process gas comprising N_2 into the chamber controls the introduction of the N_2 to be between a rate of 0 to 4000 sccm.

7. A substrate processing system as in claim 1 further comprising computer readable program code for controlling the gas distribution system to operate for a specified time period.

8. A substrate processing system as in claim 7 wherein the computer readable program code for controlling the gas distribution system to operate for a specified time period comprises computer readable program code for causing the first plasma enhanced CVD layer to be formed to a thickness which is an odd multiple, greater than one, of a wavelength of light to be used in a subsequent process operation on the layer.

9. A substrate processing system as in claim 2 wherein the computer readable program code for causing the gas distribution system to introduce the first process gas comprising a mixture of SiH_4 and N_20 into the chamber controls the introduction of the SiH_4 to be between 15 to 160 sccm, and the rate of N_20 to be between a rate of 15 to 160 sccm.

10. A substrate processing system as in claim 9 further comprising:

computer readable program code for causing the gas distribution system to introduce a third process gas comprising NH_3 into the chamber at a rate of less than 150 sccm; and

computer readable program code for causing the gas distribution system to introduce a fourth process gas comprising N_2 into the chamber at a rate of less than 300 sccm.

44. A substrate processing system, comprising:

a process chamber;

a substrate support, located within the process chamber, for supporting a substrate;

a power supply;

a gas delivery system for delivering process gases into the process chamber;

a controller configured to control the power supply and the gas delivery system; and

a memory coupled to the controller comprising a computer readable medium having a computer readable program embodied therein for directing operation of the substrate processing system, the computer readable program including a first set of computer instructions for controlling the gas delivery system to introduce selected deposition gases into the process chamber at deposited gas flow rates, a second set of computer instructions for controlling the gas delivery system to add a flow of an inert gas to the selected deposition gases at a flow rate previously determined to achieve a desired low deposition rate from a plasma enhanced reaction of the selected deposition gases, the desired low deposition rate being lower than a deposition rate using the selected deposition gases at the deposition gas flow rates with a lower flow rate of the inert gas, and a third set of computer instructions for controlling the power supply to supply power to the process chamber to produce a plasma enhanced reaction of the deposition gases in the process chamber to deposit a film at the low deposition rate.

45. The substrate processing system of claim 44 wherein the inert gas comprises helium.

46. The substrate processing system of claim 44 wherein the selected deposition gases comprise silane and an oxygen source.

47. The substrate processing system of claim 44 wherein the selected deposition gases comprise silane and nitrous oxide.

48. The substrate processing system of claim 44 wherein the selected deposition gases comprise silane and a nitrogen source.

49. The substrate processing system of claim 44 further comprising a vacuum system for controlling pressure within the process chamber, and wherein the computer-readable program further comprises a fourth set of computer instructions for controlling the vacuum system to maintain a chamber pressure in the range of 1-6 Torr, and wherein the selected deposition gases comprise SiH_4 flowed into the chamber at a rate of 5-300 sccm and N_2O flowed into the chamber at a rate of 5-300 sccm.

50. The substrate processing system of claim 49 further comprising a heater for heating the substrate, and wherein the computer-readable program further comprises a fifth set of computer instructions for controlling the heater to heat the substrate to a temperature in the range of 200-400°C.

51. The substrate processing system of claim 50 wherein the substrate support is spaced from the gas distribution system at a distance in the range of 200-600 mils.

52. The substrate processing system of claim 49 wherein the selected deposition gases further comprise NH_3 flowed into the chamber at a rate of less than 300 sccm, and N_2 flowed into the chamber at a rate of less than 4000 sccm.

53. A substrate processing system, comprising:

a process chamber;

a substrate support, located within the process chamber, for supporting a substrate;

an RF power supply;

a heater;

a gas delivery system for delivering process gases into the process chamber;

a controller configured to control the power supply and the gas delivery system; and

a memory coupled to the controller comprising a computer readable medium having a computer readable program embodied therein for directing operation of the substrate

processing system, the computer readable program including a first set of computer instructions for controlling the gas delivery system to flow He into the process chamber at a selected flow rate to provide a chamber pressure in the range of 1-6 Torr, a second set of computer instructions for controlling the RF power supply to supply power of 50-500 Watts to the process chamber, a third set of computer instructions for controlling the heater to heat the substrate to a temperature in the range of 200-400°C, a fourth set of computer instructions for controlling the gas delivery system to flow SiH_4 at a flow rate of 5-300 sccm into the process chamber, and a fifth set of computer instructions to flow N_2O at a flow rate of 5-300 sccm into the process chamber, wherein a ratio of the selected flow rate of He to the combined flow rate of SiH_4 and N_2O is at least 6.25:1 to deposit an antireflective layer on the substrate at a deposition rate which is lower than a deposition rate using the same flow rate of SiH_4 and the same flow rate of N_2O with a lower flow rate of He.

54. A substrate processing system, comprising:

a process chamber;

a substrate support, located within the process chamber, for supporting a substrate;

a power supply;

a gas delivery system for delivering process gases into the process chamber;

a controller configured to control the power supply and the gas delivery system; and

a memory coupled to the controller comprising a computer readable medium having a computer readable program embodied therein for directing operation of the substrate processing system, the computer readable program including a first set of computer instructions for controlling the gas delivery system to flow selected deposition gases into the process chamber at deposition gas flow rates, a second set of computer instructions for controlling the gas delivery system to add a flow of an inert gas to the selected deposition gases at a flow rate previously determined to achieve a desired low deposition rate from a reaction of the selected deposition gases, the desired low deposition rate being lower than a deposition rate using the selected deposition gases at the deposition gas flow rates with a lower flow rate of the inert gas, and a third set of computer instructions for controlling the power

supply to supply power to the process chamber to react the deposition gases to deposit a film at the low deposition rate.

55. A substrate processing system comprising:

a process chamber;

a substrate support, located within the process chamber, for supporting a substrate;

a gas delivery system for delivering selected deposition gases into the process chamber at deposition gas flow rates;

means for adding a flow of an inert gas to the selected deposition gases at a flow rate previously determined to achieve a desired low deposition rate from plasma enhanced reaction of the selected deposition gases, the desired low deposition rate being lower than a deposition rate using the selected deposition gases at the deposition gas flow rates with a lower flow rate of the inert gas; and

means for depositing a thin film at the low deposition rate from a plasma enhanced reaction of the deposition gases.

56. The system of claim 55 further comprising:

means for maintaining a chamber pressure of the process chamber in the range of 1-6 Torr; and

means for heating the substrate to a temperature in the range of 200-400°C.

57. A substrate processing system comprising:

a processing chamber;

a substrate support, located within the processing chamber, for supporting a substrate;

means for flowing He into the processing chamber at a selected flow rate to provide a chamber pressure in the range of 1-6 Torr;

means for connecting the chamber to an RF power supply to receive 50-500 Watts;

means for heating the substrate to a temperature in the range of 200-400°C;

means for flowing SiH_4 through a gas distribution system at a flow rate of 5-300 sccm; and

means for flowing N_2O through the gas distribution system at a flow rate of 5-300 sccm, wherein a ratio of the selected flow rate of He to the combined flow rate of SiH_4 and N_2O is at least 6.25:1 to deposit an antireflective layer on the substrate at a deposition rate which is lower than a deposition rate using the same flow rate of SiH_4 and the same flow rate of N_2O with a lower flow rate of He.

58. The system of claim 57 further comprising means for introducing NH_3 into the chamber at a rate of 0-300 sccm.

59. The system of claim 58 further comprising means for introducing N_2 into the chamber at a rate of 0-4000 sccm.

60. A substrate processing system comprising:

a substrate processing chamber;

a substrate support, located within the process chamber, for supporting a substrate;

a gas delivery system for delivering process gases into the substrate processing chamber;

means for forming an antireflective layer over a layer on the substrate by flowing selected deposition gases into the substrate processing chamber at deposition gas flow rates and adding a flow of an inert gas to the selected deposition gases to deposit the antireflective layer at a desired deposition rate which is lower than a deposition rate using the selected deposition gases at the deposition gas flow rates with a lower flow rate of the inert gas;

means for forming a layer of photoresist on the antireflective layer, the antireflective layer having a thickness and refractive indices such that a first reflection from an interface between the photoresist and the antireflective layer of an exposure light will be an odd number which is at least 3 multiplied by 180° out of phase with a second reflection from an interface between the antireflective layer and the substrate layer of the exposure light; and

means for forming a photoresist pattern by exposing the photoresist layer to the exposure light and developing the exposed photoresist layer.

61. A substrate processing system comprising:

a substrate processing chamber;

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a substrate support, located within the process chamber, for supporting a substrate;

a gas delivery system for delivering process gases into the substrate processing chamber;

means for forming an SiON antireflective layer over a first layer on the substrate by flowing selected deposition gases into the substrate processing chamber at deposition gas flow rates and adding a flow of an inert gas to the selected deposition gases to deposit the SiON antireflective layer at a desired deposition rate which is lower than a deposition rate using the selected deposition gases at the deposition gas flow rates with a lower flow rate of the inert gas, said antireflective layer having a refractive index in the range of 1.7-2.9, an absorptive index in the range of 0-1.3, and a thickness in the range of 200-3000 angstroms;

means for forming a layer of photoresist over the antireflective layer; and

means for forming a photoresist pattern by exposing the photoresist layer to an exposure light having a wavelength of 365 nm or less and developing the exposed photoresist layer, wherein a phase shift of an odd multiple of at least 3 multiplied by 180° exists between a first reflection of the exposure light from an interface between the photoresist layer and the antireflective layer and a second reflection of the exposure light from an interface between the antireflective layer and the first layer, the first reflection having almost the same intensity as the second reflection to thereby substantially cancel the first and second reflections.

62. A substrate processing system comprising:

a substrate processing chamber;

a substrate support, located within the process chamber, for supporting a substrate;

a gas delivery system for delivering process gases into the substrate processing chamber;

means for flowing selected deposition gases into the substrate processing chamber at deposition gas flow rates;

means for adding a flow of an inert gas to the selected deposition gases at a flow rate previously determined to achieve a desired low deposition rate from a reaction of the

selected deposition gases, said desired low deposition rate being lower than a deposition rate using said selected deposition gases at said deposition gas flow rates with a lower flow rate of said inert gas; and

means for depositing a thin film on the substrate at said low deposition rate from said reaction of said deposition gases.